110 Fall 2025 Test 2A Once the exam has officially started, remove the top sheet. The remaining sheets comprise your exam. It is each student's individual responsibility to ensure the instructor has received her or his completed exam. Any exams not received by the instructor earn zero points. Smart watches, phones, or other devices (except scientific calculators) are not permitted during the exam.

$V_{sphere} = \frac{4}{3}\pi R^3$	$V_{box} = LWH$	$V_{cyl} = \pi R^2 H$	$\rho = \frac{M}{V}$
$A_{sphere} = 4\pi R^2$	$V = (A_{base}) \times (height)$	$A_{circle} = \pi R^2$	$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$
$C = 2\pi R$	$A_{rect} = LW$	$A_{CylSide} = 2\pi RH$	
$160\underline{9}\ \mathrm{m} = 1\ \mathrm{mi}$	$12\ \mathrm{in} = 1\ \mathrm{ft}$	$60\ \mathrm{s} = 1\ \mathrm{min}$	$1000\ \mathrm{g} = 1\ \mathrm{kg}$
$2.54\ \mathrm{cm} = 1\ \mathrm{in}$	$1\ \mathrm{cc} = 1\ \mathrm{cm}^3 = 1\ \mathrm{mL}$	$60\ \mathrm{min} = 1\ \mathrm{hr}$	$100\ \mathrm{cm} = 1\ \mathrm{m}$
$1\ \mathrm{cm} = 10\ \mathrm{mm}$	$1\ \mathrm{yard} = 3\ \mathrm{ft}$	$3600\ \mathrm{s} = 1\ \mathrm{hr}$	$1\ \mathrm{km} = 1000\ \mathrm{m}$
$1\ \mathrm{furlong} = 220\ \mathrm{yards}$	$528\underline{0}\ \mathrm{ft} = 1\ \mathrm{mi}$	$24\ \mathrm{hrs} = 1\ \mathrm{day}$	$1\ \mathrm{rev} = 2\pi\ \mathrm{rad} = 360°$
$g = 9.8\ \frac{\mathrm{m}}{\mathrm{s}^2}$	$G = 6.67 \times 10^{-11} \frac{\mathrm{N \cdot m^2}}{\mathrm{kg}^2}$	$P_0 = 1.0 \times 10^5\ \mathrm{Pa}$	$1\ \mathrm{eV} = 1.60\underline{2} \times 10^{-19}\ \mathrm{J}$
$1\ \mathrm{N} = 1 \frac{\mathrm{kg \cdot m}}{\mathrm{s}^2}$	$1\ \mathrm{J} = 1\ \mathrm{N \cdot m}$	$1\ \mathrm{Pa} = 1\ \frac{\mathrm{N}}{\mathrm{m}^2}$	
$x_f = x_i + v_{ix}t + \frac{1}{2}a_x t^2$	$v_{fx}^2 = v_{ix}^2 + 2a_x(\Delta x)$	$v_{fx} = v_{ix} + a_x t$	$r = \sqrt{x^2 + y^2}$
$\vec{A} \cdot \vec{B} = AB \cos\theta_{AB}$	$\lVert \vec{A} \times \vec{B} \rVert = AB \sin\theta_{AB}$	$\sin(A \pm B)$ $= \sin A \cos B \pm \cos A \sin B$	$\cos(A \pm B)$ $= \cos A \cos B \mp \sin A \sin B$
$\vec{v}_{ae} + \vec{v}_{eb} = \vec{v}_{ab}$	$\hat{r} = \cos\theta\, \hat{\imath} + \sin\theta\, \hat{\jmath}$	$\hat{\theta} = -\sin\theta\, \hat{\imath} + \cos\theta\, \hat{\jmath}$	
$a_{tan} = r\alpha$	$a_c = \frac{v^2}{r} = r\omega^2$	$\vec{a} = a_r\hat{r} + a_{tan}\hat{\theta}$	$\vec{a} = a_c(-\hat{r}) + a_{tan}\hat{\theta}$
$\Sigma\vec{F} = m\vec{a}$	$f \leq \mu n$		

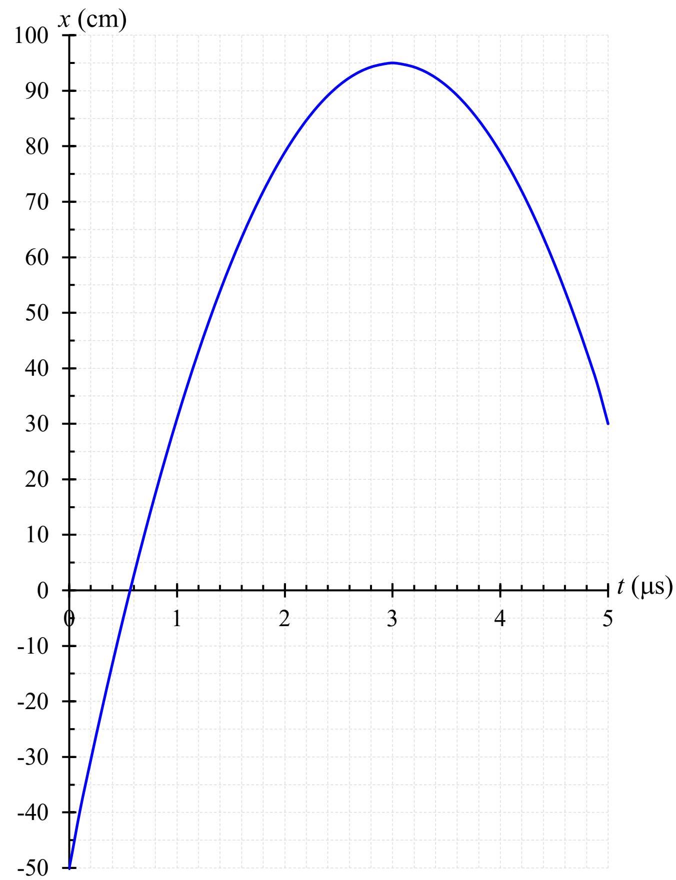
Prefix	**Abbreviation**	$\mathbf{10^?}$		**Prefix**	**Abbreviation**	$\mathbf{10^?}$
Giga	G	10^9		milli	m	10^{-3}
Mega	M	10^6		micro	µ	10^{-6}
kilo	k	10^3		nano	n	10^{-9}
centi	c	10^{-2}		pico	p	10^{-12}
				femto	f	10^{-15}

$\mathrm{M} = \text{units of mass} = \mathrm{kg}$ $\quad \mathrm{L}^2 = \text{units of area} = \mathrm{m}^2$ $\quad \mathrm{T} = \text{units of time} = \mathrm{s}$ $\quad \frac{\mathrm{L}}{\mathrm{T}^2} = \text{units of acceleration} = \frac{\mathrm{m}}{\mathrm{s}^2}$

$\mathrm{L} = \text{units of length} = \mathrm{m}$ $\quad \mathrm{L}^3 = \text{units of volume} = \mathrm{m}^3$ $\quad \frac{\mathrm{L}}{\mathrm{T}} = \text{units of velocity} = \frac{\mathrm{m}}{\mathrm{s}}$ $\quad \frac{\mathrm{L \cdot M}}{\mathrm{T}^2} = \text{units of force} = \frac{\mathrm{kg \cdot m}}{\mathrm{s}^2} = \mathrm{N}$

Name:____

A plot of position versus time for an object moving on the x-axis is shown at right. Assume the object has constant acceleration. I will assume an $\hat{\imath}$ is written on all *vector* answers for this problem (so you need not write it). Because of this, I expect to see $\pm$ signs on answers as appropriate to indicate forwards or backwards as done in class. For this problem I am ok with 2 or 3 sig figs on each answer.



1a) At what time(s), or over what time intervals, is the object instantaneously *at rest*? If it never occurs, write "never occurs".

1b) At what time(s), or over what time intervals, is this object *moving forwards*? If it never occurs, write "never occurs".

1c) Determine the *initial position* of the object.

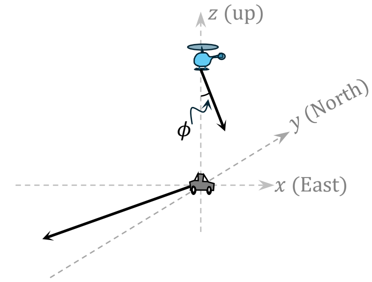
1d) Is the object's *acceleration* positive, negative, or zero? Circle the best answer.

$a_x > 0$	$a_x < 0$	$a_x = 0$	Initially $a_x > 0$ then it switches to $a_x < 0$	Initially $a_x < 0$ then it switches to $a_x > 0$	Impossible to determine without more information	None of the other answers is correct

1e) Determine *distance traveled* by this object over the entire time interval shown.

1f) Determine the object's *velocity* at $t = 4.80$ s. **Answer without any prefixes in scientific notation.

At one instant in time a helicopter is 88.8 m directly above a car. The helicopter moves in the xz-plane (relative to earth) with speed $6.66\,\frac{\mathrm{m}}{\mathrm{s}}$ angle $\phi = 17.77°$ shown in the figure. Relative to the earth, the car drives with speed $33.3\,\frac{\mathrm{m}}{\mathrm{s}}$ heading $22.2°$ west of south.



2a) Write the velocity of the helicopter (relative to earth) in Cartesian form.
Use a single number with 3 sig figs for each component.

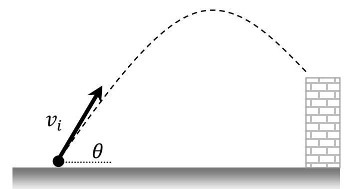
2b) Write the velocity of the car (relative to earth) in Cartesian form.
Use a single number with 3 sig figs for each component.

**2c) Determine the *speed* of the car *relative to the helicopter*.

2d) Determine the *direction* of the car's motion *relative to the helicopter*. **Answer with a unit vector.

2a	
2b	
2c	
2d	

A ball is thrown from the ground to the top of a building. The launch *speed* is v_i and the launch angle is θ. The ball takes the path shown by the dotted line. **Assume we are using a standard coordinate system (to the right is $+\hat{\imath}$ and up is $+\hat{\jmath}$).** Assume air resistance is negligible. Assume initial launch height is also negligible.



3a) Which of the following answers are correct ways to describe the acceleration of the ball at max height? More than one answer *may* be correct…*maybe not*. Circle the best answer *or answers.* Read all answers…

$a_x = +g$ & $a_y = 0$	$a_x = 0$ & $a_y = +g$	$a_x = 0$ & $a_y = 0$
$a_x = -g$ & $a_y = 0$	$a_x = 0$ & $a_y = -g$	$\vec{a} = 0\hat{\imath} + 0\hat{\jmath}$
$\vec{a} = 9.8\frac{\text{m}}{\text{s}^2}\hat{\imath} + 0\hat{\jmath}$	$\vec{a} = 0\hat{\imath} + 9.8\frac{\text{m}}{\text{s}^2}\hat{\jmath}$	None of the other answers is correct
$\vec{a} = -9.8\frac{\text{m}}{\text{s}^2}\hat{\imath} + 0\hat{\jmath}$	$\vec{a} = 0\hat{\imath} - 9.8\frac{\text{m}}{\text{s}^2}\hat{\jmath}$	

3b) Determine velocity at max height? Answer as a vector in Cartesian form using $\hat{\imath}$ & $\hat{\jmath}$. For example, if velocity at max height is zero, write $\vec{v}_{max} = 0\hat{\imath} + 0\hat{\jmath}$. If the velocity at max height is *non-zero*, use the variables v_i, θ, and/or g in your answer.

3b	

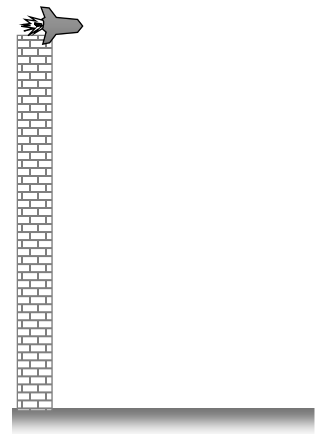
3c) Which statement best relates impact *speed* (v_f) to launch *speed* (v_i)? Circle the best answer.

$v_i < v_f$	$v_i = v_f$	$v_i > v_f$	Impossible to determine without more information

3d) Which statement best relates time *to max height* (t_{max}) to time *for the entire flight* (t_{total})? Circle the best answer.

$t_{total} < 2t_{max}$	$t_{total} = 2t_{max}$	$t_{total} > 2t_{max}$	Impossible to determine without more information

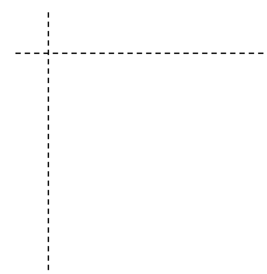
A rocket is launched from the top of a 40.0 m tall building. At the instant the rocket leaves the roof it moves horizontally with speed $8.00\,\frac{\mathrm{m}}{\mathrm{s}}$. The rocket thruster causes constant acceleration $\vec{a} = +6.00\,\frac{\mathrm{m}}{\mathrm{s}^2}\hat{\imath} - 12.00\,\frac{\mathrm{m}}{\mathrm{s}^2}\hat{\jmath}$. To be clear, this acceleration vector accounts for the combined effects of air resistance, thrust, and gravity. **Assume we are using a standard coordinate system (to the right is $+\hat{\imath}$ and up is $+\hat{\jmath}$).** You need not include $+\hat{\imath}$ and $+\hat{\jmath}$ on your answers…I will assume they are implied on answers when appropriate. Round all final answers to three sig figs.



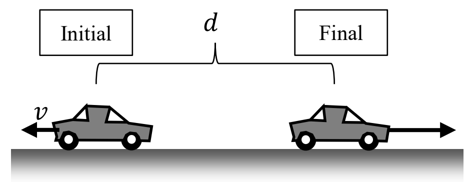
4a) What is vertical *displacement* of the rocket just before impact?

**4b) Determine time to impact.

***4c) Determine impact *velocity*. Answer in polar form (*magnitude* & direction). To clarify your answer, sketch the final answer in the box provided and label the angle.

4a	
4b	
4c	

A toy car experiencing constant acceleration moves with speed v *to the left*.
A short time later, the toy car is moving *to the right* with 67.5% *more* speed.
At this instant, the toy car is distance d to the right of its initial position.
I will assume to the right is positive and $\hat{\imath}$ is implied as appropriate.
I will be looking for appropriate $\pm$ signs on your answers.



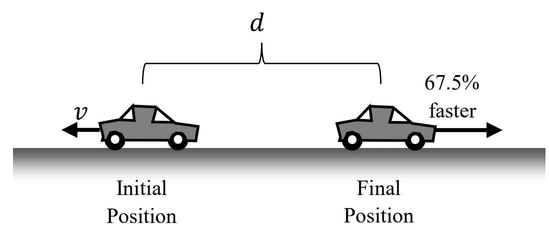
**5a) Determine acceleration of the car.
Answer with an expression involving v & d times a number with three sig figs.

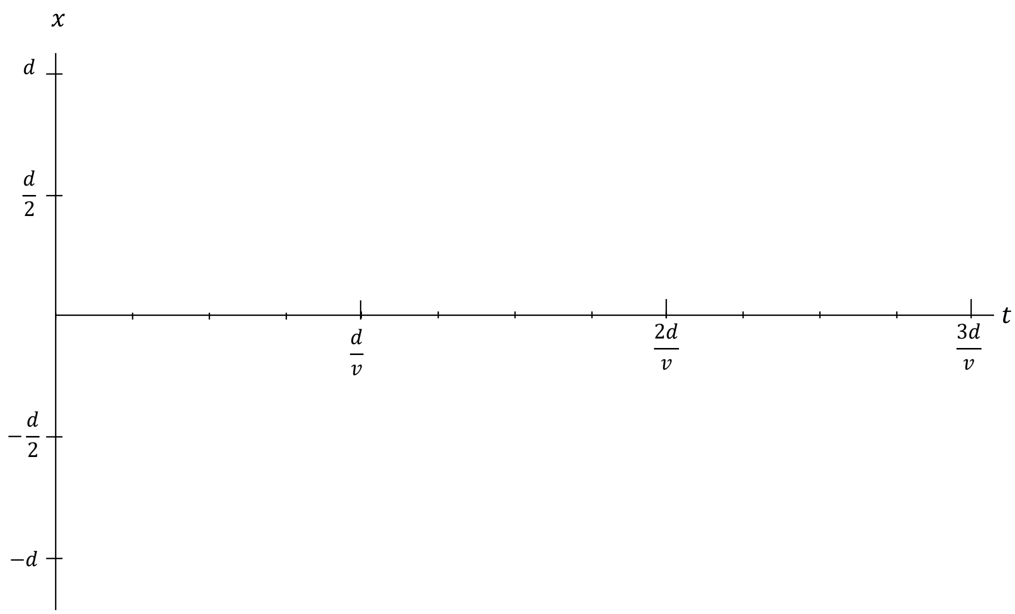
**5b) Determine the time required for the car *to reverse direction*.
Answer with an expression involving v & d times a number with three sig figs.

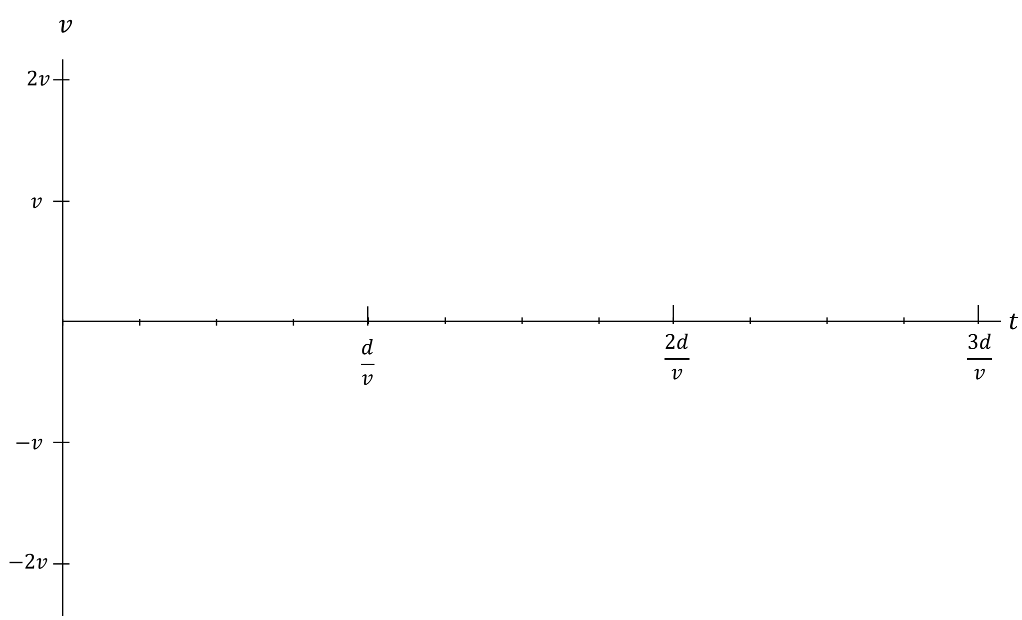
*5c) Determine distance traveled before the car reverses direction.
Express your final answer as a three sig fig number times d.

5a	
5b	
5c	

Extra Credit: Reconsider the motion of the toy car in problem 3. Assume the car is initially located at the origin.
Sketch plausible plots of position versus time and velocity versus time for the toy car as it travels from its initial position to the final position shown in the figure. Note: exam scores over 100% are not possible.







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